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THE RECTAL TRACHEATION AND RECTAL RESPIRATION OF THE LARVÆ OF  
ODONATA ZYGOPTERA.

I. RECTAL TRACHEATION OF ARGIA PUTRIDA LARVA.

BY ANNA M. CULLEN.

*Argia moesta putrida* Hagen is a Zygopterous dragonfly of wide distribution throughout the eastern United States. Its larvæ occur in flowing streams, the material studied having been collected at Cobb's Creek near Beechwood Park, Pennsylvania, May 25, 1914. The larva sectioned was killed in hot Gilson (Bolles Lee, *Microtometist's Vade Mecum*, Third Edition p. 472). It was stained with Delafield's hæmatoxylin and alcoholic eosin. The rectal tracheation was studied from a series of paraffin sections extending through the sixth, seventh, eighth and ninth segments of the larva.

The *alimentary canal* in this region will be considered first. At the beginning of the hind gut, in the posterior part of the sixth segment, the epithelium has six deep longitudinal folds. In this region the epithelium is somewhat thin. In the anterior half of the seventh segment the alimentary canal is triangular in section. This triangular appearance is caused by three patches of thickened epithelium, one dorsal in position, the others right ventral and left ventral. Between the three patches of thickened epithelium are small areas of thin pigmented epithelium. Tracheæ penetrate the thickened epithelium. No tracheæ enter the thin pigmented epithelium. The alimentary canal in the posterior half of the seventh segment and the beginning of the eighth segment is extremely thin-walled. Toward the middle of segment seven the patches of thickened epithelium disappear and the alimentary canal becomes thin-walled and folded. At first the folds have no definite arrangement but gradually six definite folds appear, three large ones alternating with three small ones. The six folds soon become equal in size and using the clock face notation of Tillyard, the folds occupy the positions of 2, 4, 6, 8, 10, and 12 of the clock face. Toward the posterior end of segment seven the folds gradually disappear and the alimentary canal is thin-walled, and oval, almost rectangular in outline. This part of the larva contains few of the smaller tracheæ, none of which approach the alimentary canal. In the anterior part

of segment eight, the longitudinal rectal folds begin to appear in the epithelium. These folds become deeper and extend all through segment eight and part of segment nine. Of the three folds, one is dorsal, one may be called right latero-ventral and the third left latero-ventral (Fig. 1); in spite of their positions, shown in this figure, they appear to correspond to folds 12, 4, and 8 of the clock face. Between the folds there are thin pigmented areas. Toward the posterior end of segment nine and continuing through segment ten, the folds become gradually less pronounced until they form merely three thickened areas of the rectal wall. Between these areas of thickened epithelium, the rectal wall is extremely thin and projects inward as a ridge. Since there are three areas of thickened epithelium, of course there are three of these thin inwardly projecting ridges. All along through segments eight and nine tracheæ penetrate the thickened epithelium but no tracheæ enter the thin areas. Toward the middle of the ninth segment the thin epithelium between the longitudinal folds becomes spongy. These spongy masses continue through the ninth segment and into the tenth segment. In the latter half of the ninth segment tracheæ penetrate these spongy masses.

#### TRACHEAL SYSTEM.

There are two great dorsal longitudinal tracheæ, called right dorsal trachea, *rdt*, and left dorsal trachea, *ldt*, and two longitudinal lateral tracheæ, *rlt* and *llt*. In the anterior part of segment eight (Fig. 2), each lateral trachea gives off a visceral trachea, the right visceral trachea, *rvs*, and the left visceral trachea, *lvs*, respectively. These extend ventrad, mesad and cephalad in the seventh segment. For some distance there is no branching, but when the right visceral trachea and the left visceral trachea change their course somewhat and each takes up a lateral position a little farther forward, each begins to branch. The branches of the right visceral trachea supply the thickened epithelium on the right side of the alimentary canal, divide and subdivide and finally the smallest tracheoles shown in the diagram penetrate the epithelium. In like manner the branches of the left visceral trachea supply the thickened epithelium of the left side of the alimentary canal. The dorsal thickened epithelium is supplied by small tracheæ whose origin is from another branch of the left visceral trachea.

About the middle of the eighth segment each dorsal trachea gives off a branch, the right dorsal rectal trachea, *rdrt*, and the left dorsal

rectal trachea, *ldrt*<sub>1</sub>, respectively. Each of these runs mesad and caudad and enters the dorsal longitudinal fold of the alimentary canal (Fig. 1). Here these tracheæ divide and subdivide, but no anastomosis between the tracheoles of the right dorsal rectal trachea and the left dorsal rectal trachea was found.

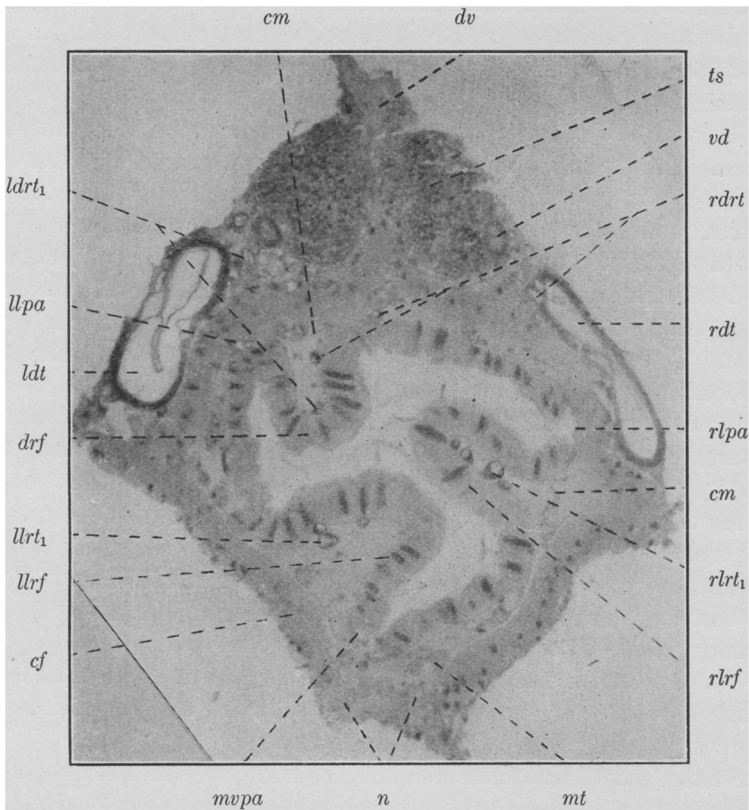


Fig. 1. Transverse section of abdomen of larva of *Argia moesta putrida* ♂ near the middle of the 7th segment (TS. 52, row 4, slide 3) seen from its posterior face. Cuticle and hypodermis removed before embedding. Photographed by Mr. H. A. Walters, using Leitz ocular 4, objective 3. Enlarged 117 diameters.

*cf*, connective tissue and fat.  
*cm*, circular muscles of gut wall.  
*drf*, dorsal rectal fold.  
*dv*, dorsal vessel.  
*ldrt*<sub>1</sub>, left dorsal rectal trachea.  
*ldt*, left dorsal trachea.  
*llpa*, left lateral pigmented area.  
*llrf*, left lateral rectal fold.  
*llrt*<sub>1</sub>, left lateral rectal trachea.  
*mt*, Malpighian tubule.

*mvpa*, mid-ventral pigmented area.  
*n*, nerve.  
*r*, rectum.  
*rdrt*, right dorsal rectal trachea.  
*rdt*, right dorsal trachea.  
*rlpa*, right lateral pigmented area.  
*rlrf*, right lateral rectal fold.  
*rlrt*<sub>1</sub>, right lateral rectal trachea.  
*ts*, testis.  
*vd*, vas deferens.

Some distance anterior to the origin of the dorsal rectal tracheæ there arises, on each side, the right lateral rectal trachea, *rlrt*<sub>1</sub>, and the left lateral rectal trachea *llrt*<sub>1</sub>, from the right visceral trachea and left visceral trachea respectively, at a point just mesad of the origin of each visceral trachea from the lateral trachea. The right lateral rectal trachea extends caudad and sends branches cephalad and caudad which enter the right longitudinal rectal fold. In like manner the left lateral rectal trachea supplies the left longitudinal rectal fold (Fig. 1).

Toward the end of the ninth segment a dorsal trachea appears, *ldrt*<sub>11</sub>. This originates from the left median caudal gill trachea, *lmcgt*, at the end of the ninth segment. It sends a branch caudad which penetrates the rectal epithelium in the anterior part of the tenth segment. Another branch extends cephalad giving off branches and penetrates the rectal epithelium about the middle of the ninth segment. No trachea corresponding to *ldrt*<sub>11</sub>, appears on the right side. Toward the end of the ninth segment small tracheæ are noticed in the spongy masses between the longitudinal folds of the rectum. The trachea in the ventral mass originates from a branch of the left lateral trachea at the hind end of the ninth segment. This little trachea extends mesad and cephalad and disappears in the ventral spongy mass about the middle of the ninth segment. The trachea of the left spongy mass originates at the end of the ninth segment from the left dorsal rectal trachea *ldrt*<sub>11</sub>. It runs cephalad a very short distance and disappears in the left spongy mass. The trachea of the right spongy mass originates at the end of the ninth segment from the right median caudal gill trachea, *rmcgt*. It extends mesad and cephalad a short distance in the right spongy mass where it disappears.

At the end of the ninth and the beginning of the tenth segment there is an anastomosis between the right and left lateral longitudinal tracheæ which meet in the midventral line. Two other tracheæ also take part in this anastomosis. These are a branch from the right and a branch from the left lateral caudal gill tracheæ, *rcgt* and *lcgt*, respectively.

"Observation and experiment with carmine particles on living larvae of *Argia moesta putrida* from the vicinity of Philadelphia showed that a larva watched for two hours may give no sign of *rythmic* rectal contractions, but that these may suddenly begin and then continue for varying periods. They consisted of sets of three rapidly successive contractions, every third contraction being

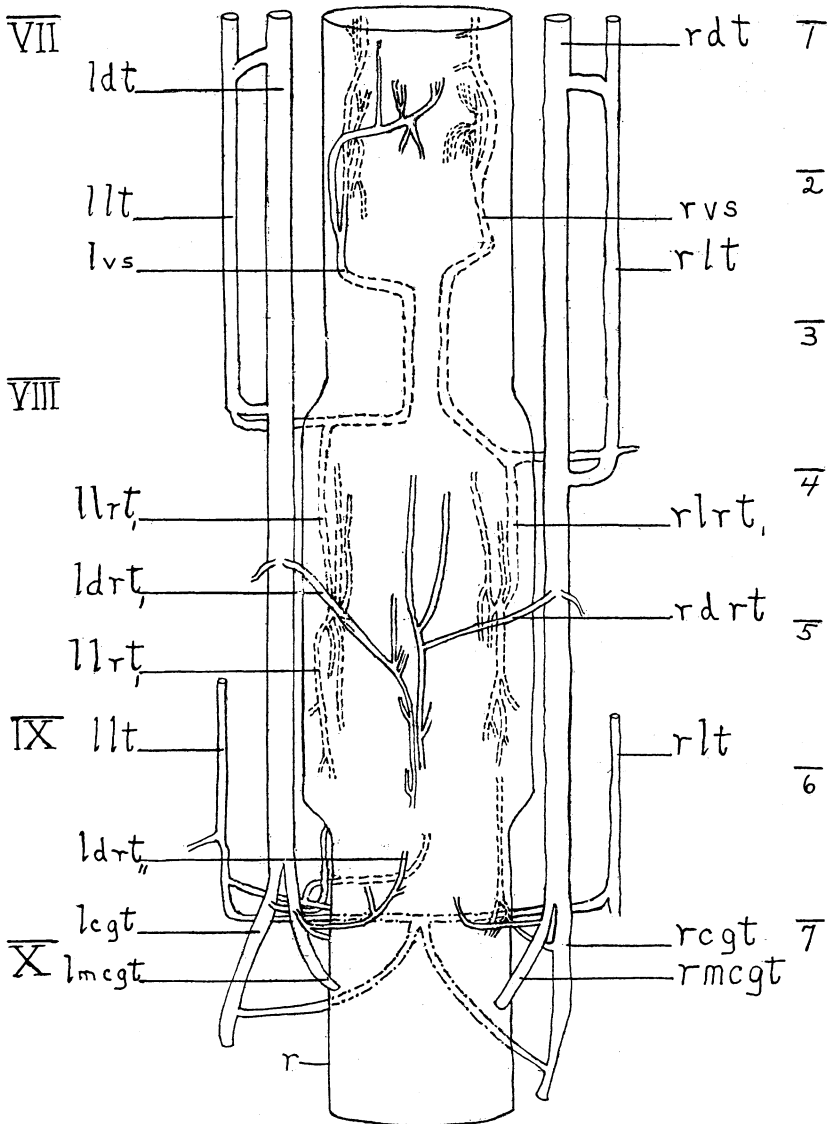


Fig. 2. Diagram of tracheation of the hind-gut of larva of *Argio moesta putrida*, reconstructed from sections. To avoid confusion the tracheæ are represented as lying farther to right and to left from the gut and from each other than is actually the case (compare Fig. 1). Of the tracheæ which supply the gut walls, those which run on the dorsal surface or enter the dorsal longitudinal fold are shown in solid lines; those which run on the ventral surface or enter the lateral folds are shown in broken lines. The tracheæ forming the ventral anastomosis are shown by alternating dots and dashes. The Roman numerals on the left side indicate the anterior ends of the respective abdominal segments, the Arabic numerals on the right the beginning of each row of sections on slide 3 of the series; each row comprises about 60 sections. Abbreviations as in Fig. 1, and as given in the text.

of longer duration than the other two; 32 such sets per minute were noted. At other times sets of five contractions were noted. In some larvae, but not in all, the beginning of a set of rectal contractions was often synchronous with a slight shortening of the abdomen; the lengthening of the abdomen began before the contractions had ended. A rhythmic shortening and lengthening of the abdomen may perhaps furnish an indication of the existence of rectal contractions in an opaque larva. Successive removal of the three caudal gills in one larva was not followed by any immediate beginning of rectal contractions, although such were seen four hours later; the larva was not under continuous observation during all of that time, however." (Calvert, *Ent. News*, XXVI, pp. 441-2.)

In the diagram of the rectal tracheation of *Thaumatonereura* larva figured by Calvert, Plate XVI, *Ent. News*, Vol. XXVI, there is one area of rectal respiration supplied by the right and left dorsal rectal tracheæ and the right and left lateral rectal tracheæ. It seems from the structure of *Argia putrida* larva that there may be two areas of respiration in the alimentary canal walls, a small one in segment seven and a larger respiration area in segments eight and nine. The respiration of the seventh segment may be carried on through the tracheæ supplied by the branches of the right and left visceral tracheæ. The larger respiration area of segments eight and nine is supplied with tracheæ through the branches of the right and left dorsal rectal tracheæ and the right and left lateral rectal tracheæ. In each case the structure of the epithelium of the alimentary canal appears to be the same. In the seventh segment, the three patches of thickened epithelium supply the surface through which respiration may take place. In the eight and ninth segments, the thickened epithelium of the longitudinal rectal folds supplies the surface through which respiration may take place (Fig. 1).

At the present time there is considerable doubt in the minds of observers as to the importance of these areas of respiration. When the caudal gills have been removed, the *Argia putrida* larva continues to live. Respiration may take place all over the surface of the body through the thin body wall. If this is the case, then we may assume that respiration also takes place throughout the length of the hind gut through its wall. The numerous tracheæ found penetrating the thickened epithelium can be explained as necessary because respiration is more difficult in these regions owing to the thickness of the walls, hence the many tracheoles penetrating the thickened epithelium. A comparison with the rectal respiration

areas of Anisopterid larvae seems to strengthen this view. In the rectal gills of these larvae, the minute branches of the tracheæ are separated from the water of the rectum by a very thin epithelium. This seems to show that respiration takes place most actively through a thin epithelium.

## II. THE TRACHEAL SUPPLY OF THE RECTUM OF THE LARVA OF ARGIA TALAMANCA FROM JUAN VIÑAS, COSTA RICA.

BY JANET P. JAMIESON.

The rectal epithelium of the water-fall dweller, *Argia talamanca*, presents three main longitudinal folds, one that is "dorsal and a little to the left of the median plane," a second that is "left latero-ventral" and the third that is "right lateral." These folds (Fig. 1.) correspond in position with those of the water-fall dweller *Thaumatoneura* described by Calvert (*Entomological News*, Vol. XXVI, p. 387, and plate XVII, fig. 1.) Those of *A. talamanca* are, however, deeper as may be seen by comparing photographs of the transverse sections, and show a greater complexity. In some parts of the rectum the free edges of the three folds appear to meet in the center of the lumen of the gut. Between the bases of these primary folds the epithelium thins out and becomes darkly pigmented. From the base of each primary fold, is given off a secondary shallower fold, to the right in the case of the dorsal fold, to the left in the case of the left latero-ventral fold and ventrally in the case of the right lateral fold.

Toward the hind end of the rectum the secondary folds disappear and the main folds have practically no depth; this gives an almost cylindrical shape to the hind part of the rectum.

The larva of *Argia putrida* from the vicinity of Philadelphia, described in the preceding paper by Miss Cullen, differing from *A. talamanca* in that it lives in streams of continuously flowing water, shows three simple shallow folds in the rectal epithelium, one dorsal, one right lateral and one left lateral. The epithelium is much denser and thicker than in this water-fall dweller of the same genus, and the thin pigmented areas between the bases of the folds are not so broad.

It has been suggested by Calvert that the more extensive surface area afforded by the greater folding of the rectum together with the thinner, less dense nature of the epithelium of the water-fall dwellers may aid these larvae materially in procuring a supply of